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(54) HIGH FREQUENCY CIRCUIT**(57)Abstract:**

PROBLEM TO BE SOLVED: To provide a high frequency circuit that is suitable for a front end application of a receiver receiving pluralities of high frequency signals and where a changeover switch configuration among pluralities of blocks processing each high frequency signal is simplified so as to attain miniaturization and switches are formed integrally with other high frequency transistors (TRs) such as a GaAsFET.

SOLUTION: Each of pluralities of circuit blocks 21, 22 is provided with DC switch TRs Qs1, Qs2 for DC switch shutting a path of a DC bias current (i) supplied in a circuit block not selected based on a non-selection signal. A common load element Rss between the blocks is connected between sources of the TRs Qs1, Qs2 and a common level. In the case of a high frequency mixer circuit, an RF input terminal is used for each block and an LO input terminal and an IF output terminal are used in common for the blocks.

Furthermore, each block includes DC switch TRs Qs1, Qs4 and has input output interrupt sections that shut a DC current path in the case of non-selection to sufficiently attain high frequency isolation between the input and output terminals.

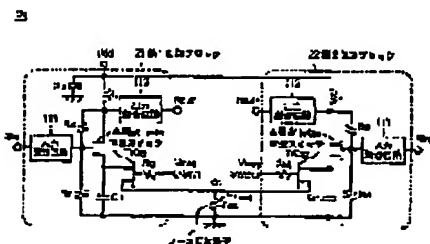
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10-313259 DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] It is related with that plurality of this invention, such as a receiving system of the receiving set or mobile communications which has for example, a diversity antenna, is the same, or the RF circuit which inputs a different RF signal and processes magnification, frequency conversion, etc., respectively.

[0002]

[Description of the Prior Art] In the receiving set in the field of radio, in order to realize correspondence to two or more systems by which antenna diversity differs from a frequency etc., two or more low noise amplifiers, mixers, etc. which are the front end are prepared beforehand, one path is alternatively operated from the inside, and other paths are used from the selected path concerned in many cases, intercepting them in RF.

[0003] There are mobile communications represented with the radio as which these system correspondences of two or more are required by the cellular phone as what is splendidly developed in recent years. for example, domestic -- setting -- the analog of the 800MHz band from the former -- cellular -- adding -- new -- digital ones of a 800MHz band and a 1.5GHz band -- being cellular (PDC) -- it was put in practical use and the personal handicap phon system (PHS) has begun service from several years before. Moreover, various methods exist in Europe and each U.S. overseas. thus, even if it comes out of a word and calls it mobile communications, the system is various and assignment of a frequency also differs. And the ED which enables it to receive service by two or more of these systems with one personal digital assistant has also already started, and it is in the situation commercialized soon.

[0004] When one terminal tends to realize transmission and reception of two or more systems, it is RF (Radio-Frequency). A difference of the frequency by the system is most influenced in a stage. the first rank to which it performs frequency conversion that it is especially thought that the effect of a difference of this frequency is the largest by the receiving system -- the mixer section -- it is -- usually -- the first rank -- the mixer section is divided every [system (frequency band to be used)], and is constituted. It is because it is necessary to prepare the narrow-band band-pass filter which passes only the RF signal of a use band for the secondary distortion oppression by the image band or halfIF in the mixer section preceding paragraph in the mixer section. It is an important technical problem how on the other hand, miniaturization and low-power-ization are attained as the personal digital assistant driven with a dc-battery, it has the RF property which was excellent for this reason, and development of the mixer section by GaAsMMIC (Monolithic microwave integrated circuits) advantageous to low-power-izing is furthered briskly. this semantics since it boils the frequency bandwidth which can acquire the RF property excellent in the low power comparatively and is narrow when the mixer section is realized by GaAsMMIC -- the first rank -- the need of dividing the mixer section into the block for every frequency band, and constituting it is high.

[0005] the first rank which drawing 9 can receive [of conventional two or more systems] -- as the example of a configuration of a mixer circuit -- RF1 RF2 ** -- two said RF signals are chosen and the block diagram of the mixer circuit corresponding to a dual band in which the down convert of a frequency is possible is shown. This conventional mixer circuit 100 The 1st mixer circuit block 101, LO input terminal LOin1 of the 2nd mixer circuit block 102 and both mixer circuit block 101, 102 LOin2 It connects in between. LO input high frequency switch 103 which changes alternatively the input direction of the oscillation signal (LO signal) from the local oscillator which is not illustrated, It connects among the output terminals IFout1 and IFout2 of the mixer circuit blocks 101 and 102, and consists of IF output high frequency switches 104 which change an output. and RF input terminal RFin1 of the mixer circuit blocks 101 and 102 RFin2 **** -- the narrow band filter 105, 106 with which passbands

differ, respectively communalizes an input, and is connected,

[0006] Each of two mixer circuit blocks 101 and 102 consists of mixer 101a or 102a, LO buffer amplifier 101b or 102b, and IF amplifier 101c or 102c.

[0007] Two high frequency switches 103 and 104 consist of an FET switch of GaAs, or a diode switch of Si, respectively. Drawing 10 is the circuit diagram showing the general example of a configuration of the high frequency switch which used GaAsFET. This high frequency switch is a control signal CTL1 between the 1st wired-AND capacity Cout1 connected to the coupling capacity Cin connected to the input terminal RFin, and the 1st output terminal RFout1. 1st FETQ1 for a transfer switch through which it is inputted into the gate and flows It connects. Similarly, it is a control signal CTL1 between the 2nd wired-AND capacity Cout2 connected to the 2nd output terminal RFout2, and said coupling capacity Cin. Control signal CTL2 of opposition 2nd FETQ2 for a transfer switch through which it is inputted into the gate and flows It connects. The 1st wired-AND capacity Cout1 and 1st FETQ1 for a transfer switch In a connection node, it is the 2nd control signal CLT2 between touch-down potentials, 3rd FETQ3 through which it flows Capacity C3 for RF touch-down Series connection is carried out. Similarly, they are the 2nd wired-AND capacity Cout2 and 2nd FETQ2 for a transfer switch. In a connection node, it is the 1st control signal CLT1 between touch-down potentials. 4th FETQ4 through which it flows Capacity C4 for RF touch-down Series connection is carried out. moreover, between this two connection node grounded in high frequency and two objects FETQ1 and Q2 for a transfer switch Between a node and touch-down potentials and control signals CTL1 and CTL2 each input path -- respectively -- illustration -- like -- resistance R40-R49 -- connection -- now, it is. Thus, by the constituted high frequency switch, they are one objects FETQ1 or Q2 for a transfer switch. If it changes to switch-on alternatively, FET for a transfer switch of another side will change to non-switch-on, and high frequency touch-down of the output terminal side will be carried out. For this reason, the signal inputted from an input terminal RFin is drawn and outputted to one output terminal, without revealing to the output terminal side of another side.

[0008] By the way, in the receiving set in the field of radio, various amplifier is built in front end magnification also in the receiver which carries out the multiple input of the same RF signals, such as other, for example, an antenna, diversity for signal magnification of a different frequency band called the various amplifier within the above-mentioned mixer circuit block.

[0009] The basic configuration of one step of RF amplifying circuit is shown in drawing 11 as the easiest example. Moreover, to drawing 12, the case where the basic amplifying circuit of drawing 1 is made to build in each circuit block is illustrated in the receiving set with which two inputs are. The high frequency amplifying circuit 110 of the one-step configuration shown in drawing 11 consists of the transistor Q30 for high frequency magnification, an input matching circuit 111, an output matching circuit 112, and a bias circuit. Moreover, the auto-bias method using source resistance the simplest as a means of drain bias current stabilization of the transistor Q30 for high frequency magnification and general is adopted.

[0010] Between a power supply terminal Vdd and touch-down potential, they are the load inductor L, the transistor Q30 for high frequency magnification, and the source resistance component Rs. It is made to connect with a serial. The capacitors C10 and C11 for high frequency touch-down are connected between a power supply terminal Vdd and touch-down potential, respectively between the source of the transistor Q30 for high frequency magnification, and touch-down potential. The gate of the transistor Q30 for high frequency magnification has resistance R31 between resistance R30 and touch-down potential between the drain, and bias voltage is set up with the partial pressure. Moreover, they are the drain of said input matching circuit 111 and the transistor Q30 for high frequency magnification, and the RF output terminal Tout between the gate of the transistor Q30 for high frequency magnification, and the RF input terminal RFin. Said output matching circuit 112 is connected

in between, respectively. In addition, it is constituted about the I/O matching circuit 111,112 by the reactive circuit which usually used the inductor and the capacitor.

[0011] Drawing 12 shows the case where it has the amplifying circuit of drawing 11 in two blocks which make the first step of the receiving set of a two-line input. This first step 120 has the 1st circuit block 121 and the 2nd circuit block 122, and is equipped with the current supply change section 123 which activates only one circuit block alternatively as a general means which changes those supply voltage supply paths. Each circuit block 121,122 has the basic configuration of drawing 11, and is the RF input terminal RFin1 for every circuit block. Or RFin2 The RF output terminal RFout1 or RFout2, and power supply terminal Vdd1 Or Vdd2 It is prepared. Both these power supply terminals Vdd1 and Vdd2 Said current supply change section 123 is connected, the control signal inputted into the control terminal Cnt by this is embraced, and the supply voltage VDD from the power-source input terminal Vdd is power supply terminals Vdd1 and Vdd2. It changes so that either may be supplied, and control is made.

[0012]

[Problem(s) to be Solved by the Invention] When a place monolithic-IC-ized a block change means especially in the receiving set of the multiple input illustrated to drawing 9 and drawing 12, the technical problem shown below occurred. first, the first rank shown in drawing 9 -- in a mixer circuit 100, although the high frequency switch 103,104 is used, in the configuration of the switch itself becoming complicated generally as shown in drawing 10 in order to fully intercept the path of LO signal or an IF signal with a high frequency switch, since the overlap part of wiring etc. influences a property, it is hard to attain the miniaturization of a switch. For this reason, the high frequency mixer circuit of a configuration was a block configuration which it is hard to attain that miniaturization, and is not suitable for integration conventionally [of having changed a block with a high frequency switch].

[0013] On the other hand, although between input/output terminals was intercepted in RF in the circuit 120 illustrated to drawing 12 by having the means of current supply electronic switch 123 grade, giving supply voltage to the power supply terminal of the block corresponding to the path which should be chosen by this, and making other intact power supply terminals into OFF, 0V [i.e.,], for this reason, the means of current supply electronic switch 123 grade needed to be established specially, and this had become a big burden on the system design.

[0014] The circuit which shows the bias current cutoff function for this block selection to drawing 13 as an amplifying circuit with which the interior was equipped is known from the former. In this amplifying circuit 130, it is what added the bias current cutoff function to the basic configuration of drawing 11. Namely, the source and source resistance Rs of the transistor Q30 for high frequency magnification In between, it is the transistor Qs for a direct-current switch. It is made to insert and the gate is connected to the switch terminal SW through resistance R32.

[0015] However, when it is going to realize this amplifying circuit 130 to a monolithic in a GaAsFET integrated circuit, the following problems arise. In order to enable actuation of an amplifying circuit 130 only by the positive supply, it is necessary to use the transistor Q30 for high frequency magnification as an enhancement type at least. Since the diffusion potential is 0.6V-0.7V in most general MBSFET as GaAsFET, the realistic pinch-off-voltage range in consideration of the high frequency property other than a DC characteristic is very as narrow as 0.1V-0.3V at most, and considering the variation in a manufacture process, utilization is difficult. On the other hand, if diffusion potentials are about 1.2 V and high JFET, the pinch-off-voltage range can expect 0.1V-0.6V at least, and even if it takes the variation in a manufacture process into consideration, it will become utilizable. However, in an actual circuit, if the operating voltage margin is taken into consideration, it will be necessary to

make still higher a pinch-off minimum electrical potential difference.

[0016] Drawing 14 is a graph which shows the switch terminal voltage V_{sw} dependency of the conversion gain at the time of building a prototype to a high frequency mixer circuit with the application of the same bias current cutoff function as drawing 13. At this example of a prototype, it is the transistor Q_s for a direct-current switch of drawing 13. Using GaAsJFET, the pinch off voltage is about 0.1V-0.2V, and supply voltage V_{DD} is 2.7V. From drawing 14, from 0V whose switch terminal voltage V_{sw} is OFF state voltage, when conversion gain becomes high, it shows a steep upward tendency, consequently it is understood that the operating voltage margin at the time of OFF is very small.

[0017] Moreover, in the same example of a prototype as drawing 14, drawing 15 measures the switch terminal voltage V_{sw} dependency of a bias current, and graph-izes the result. In drawing 15, it is the current on which the switch terminal voltage V_{sw} flows the inside of the resistance R_{30} to which the bias current of the 0V neighborhood generates the gate bias voltage of the transistor Q_{30} for high frequency magnification of drawing 13, and R_{31} from a supply voltage V_{DD} side. therefore, switch terminal voltage V_{sw0} to which, as for switch terminal voltage in case the drain current component of the transistor Q_{30} for high frequency magnification is almost equal to what deducted the bias current value in case the switch terminal voltage V_{sw} is 0V from the bias current value read in the graph and a drain current begins to flow to the transistor Q_{30} for high frequency magnification, a bias current begins to go up it is. Therefore, this electrical potential difference V_{sw0} It turns out that the pinch off voltage of the transistor Q_{30} for high frequency magnification is near, and a high frequency property changes from a graph steeply bordering on this pinch off voltage. When this margin is set to 0.3V in consideration of the operating voltage margin of a circuit at this, the pinch-off-voltage range which needed to expect about 0.4V at least as a pinch-off minimum electrical potential difference, consequently took the operating voltage margin of a circuit into consideration will become narrow suddenly compared with the pinch-off-voltage range 0.1V-0.6V based on 0.4V-0.6V, and the diffusion electrical potential difference of FET. Therefore, when the variation in a manufacture process is taken into consideration, even if it is JFET, it is difficult [it] to realize at a monolithic the single power supply circuit shown in drawing 13 on the same substrate.

[0018] This invention aims at offering the RF circuit of a new configuration of having been made in view of such the actual condition, it having been suitable for the front end application of the receiving set which can receive [the same or] two or more RF signals with which frequencies etc. differ, and having attained the miniaturization for the switch configuration for a change during two or more blocks handling each RF signal as a simple thing, and having enabled formation of the switch concerned at other transistors for RFs, such as GaAsFET, and one.

[0019]

[Means for Solving the Problem] In order to solve the trouble of the conventional technique mentioned above and to attain the above-mentioned purpose, it replaced with a conventional high frequency switch or a conventional power-source change device, and, moreover, this DC switch was made to build in in the high frequency circuit of this invention using DC switch of a configuration of that an operating voltage margin is made widely, respectively in two or more circuit blocks of each corresponding to two or more high frequency signal inputs.

[0020] That is, in the high frequency circuit of this invention, it has two or more circuit blocks into which the RF signal which received is inputted, and said two or more circuit blocks of each have the transistor for a direct-current switch which intercepts the path of a direct-current bias current of flowing the inside of the circuit block concerned based on the non-selection signal inputted, respectively, when the block is not chosen. That source is between circuit blocks, and this transistor for a direct-current switch intercepts the drain as said direct-current bias current, and the current between the sources, when it connects mutually, it

connects with the supply line of a common electrical potential difference through a common load component and said non-selection signal is impressed to the gate. Moreover, the drain of said transistor for a direct-current switch is connected to the source of the high-frequency transistor within the same circuit block as the transistor for a direct-current switch concerned, and the capacitor for RF touch-down is connected between the source of the high-frequency transistor concerned, and the supply line of said common electrical potential difference.

[0021] Such circuitry is applicable to the RF circuit where amplifying circuits, mixer circuits, etc. are various. It has two or more mixer circuit blocks which in the case of a mixer circuit mix a RF signal with local oscillation signalling frequency, and output an IF signal for every frequency band of a RF signal. It has RF input terminal into which said RF signal is inputted for said every mixer circuit block. LO input terminal which inputs said local oscillation signalling frequency, and each IF output terminal which outputs said IF signal. It is between all mixer circuit blocks, and is communalized. Said two or more mixer circuit blocks. When a RF signal peculiar to the block is not chosen. By intercepting the path of a direct-current bias current of flowing the inside of the mixer circuit block concerned based on the non-selection signal inputted, it has the I/O cutoff section which fully raises the RF-insulation of said IF output terminal to said RF input terminal at least, respectively. The I/O cutoff section in this case also has the configuration which is between blocks similarly and communalized the load component with having mentioned above preferably.

[0022] As an example of a configuration of a still more concrete mixer circuit, for example, said mixer circuit block. Supply voltage is impressed to a drain and the source is connected to said common electrical potential difference through the capacitor for RF touch-down. It has the transistor for mixers which outputs said IF signal from a drain side when said RF signal and said local oscillation signalling frequency are inputted into the gate. Said I/O cutoff section. As said transistor for a direct-current switch, when said non-selection signal is inputted into the gate, it has the transistor for an output switch which intercepts the operating current which flows to said transistor for mixers. It considers as other examples of a configuration. Moreover, in said mixer circuit block. When a RF signal is inputted from said RF-signal input terminal connected to the drain and said local oscillation signalling frequency is inputted into the gate. Supply voltage is impressed to the transistor for mixers which outputs an IF signal from the source, and a drain. The source is connected to said common electrical potential difference through the capacitor for RF touch-down. It has the transistor for IF magnification which it connects with the source of said transistor for mixers, and the gate amplifies said IF signal inputted into the gate concerned, and outputs from a drain. As said transistor for a direct-current switch, said I/O cutoff section has the transistor for an output switch which intercepts the operating current which flows to said transistor for IF magnification, when said non-selection signal is inputted into the gate.

[0023] Generally, if two different RF signals are mixed, since various frequency components are easily generated in a large frequency band, it may be difficult [it] to secure high insulation to all frequency components about the transistor for the object for mixers, or IF magnification depending on the size and structure at the time of un-flowing. For this reason, it is between the I/O within a mixer circuit block, and in order to secure certainly high insulation, it is desirable to intercept the input path of LO signal and not to perform the mixing of a signal itself. From this viewpoint, it sets for the two above-mentioned concrete examples of a configuration preferably. Said mixer circuit block. It connects between the gate of said transistor for mixers, said supply voltage supply line, or said common electrical-potential-difference supply line. It has further the transistor for LO magnification which amplifies said local oscillation signalling frequency inputted from said LO input terminal connected to the gate, and is outputted to the gate of said transistor for mixers. As said 2nd transistor for a direct-current switch, said I/O cutoff section has further the transistor for an input switch which intercepts the operating current which flows to said transistor for LO

magnification, when said non-selection signal is inputted into the gate.

[0024] When this invention is applied to a mixer circuit as mentioned above, since the drain current path is intercepted at the time of un-using it about the transistor for mixers generally constituted by the transistor for an output switch using GaAsFET, the high frequency insulation between I/O of the mixer circuit concerned is fully secured, and selection of a block becomes realizable. Moreover, the input path of local oscillation signalling frequency can be separated from the input of the transistor for mixers with the transistor for an input switch, and, thereby, the mixing itself can be stopped. The I/O cutoff section consists of some passive elements to which the fundamental configuration accompanied this with single FET. Since the source of FET for a direct-current switch of the I/O cutoff section is between blocks, interconnects in the high-frequency circuit of this invention including the case of this mixer circuit, it connects with common potential through the load component and the operating current flows into the load component concerned from the inside of block used, the source potential of the high-frequency transistor turn off within a non-use block rises, and it acts in the direction in which this expands the pinch-off-voltage range of the high-frequency transistor concerned.

[0025]

[Embodiment of the Invention] Hereafter, the RF circuit concerning this invention is explained to a detail based on a drawing. This invention relates to the RF circuit which can respond to the system which inputs the signal with which at least two or more same signals differ from a frequency band etc., as mentioned above. Therefore, although it can respond to three inputs, four inputs, or the many input system beyond it if this invention is used, here explains this invention for the case of 2 inputs to an example.

[0026] 1st operation gestalt drawing 1 is the block diagram showing the configuration of the high frequency mixer circuit corresponding to 2 systems concerning the operation gestalt of this invention. This high frequency mixer circuit 1 monolithic-izes two mixer circuit blocks 2 with which the frequency bands to deal with differ mutually, i.e., the 1st mixer circuit block, and the 2nd mixer circuit block 3, and is constituted. The 1st mixer circuit block 2 is the RF input terminal RFin1 into which the RF signal of the frequency band of a proper is inputted. It has and consists of mixer section 2a, LO buffer amplifier 2b, IF amplifier 2c, etc. Similarly, the 2nd mixer circuit block 3 is the RF input terminal RFin2 into which the RF signal of the frequency band of a proper is inputted. It has and consists of mixer section 3a, LO buffer amplifier 3b, IF amplifier 3c, etc. It is communalized and the input of LO buffer amplifier 2b and 3b is connected to the LO input terminal LOin. The output of IF amplifiers 2c and 3c is also communalized, and it is the IF output terminal IFout. It connects. In addition, LO buffer amplifier 2b and 3b are omissible, if it is when the output of the local oscillator which is not illustrated is big enough. Moreover, it can be made to build in IF digital disposal circuit which also omits IF amplifiers 2c and 3c in itself, or is connected to the latter part. RF input terminal RFin1 of the mixer circuit blocks 2 and 3 RFin2 It is the same as usual that the narrow band filters 105 and 106 with which passbands differ have an input communalized, and are connected.

[0027] Thus, in each mixer circuit blocks 2 and 3 which interconnect, they are the switch terminals SW1 and SW2, respectively. It is prepared. This switch terminal SW1 And SW2 In drawing 1, the non-selection signal which operates the I/O cutoff section of the built-in which is not illustrated is received. The I/O cutoff section intercepts the path of a direct-current bias current of flowing the inside of a mixer circuit block based on the non-selection signal inputted. IF output terminal [as opposed to the RF input terminal (RFin1 or RFin2) within a mixer circuit block / **** / by this / un-] IFout A RF-insulation is fully attained.

Consequently, the down convert of a frequency is performed by the selection mixer circuit block into which a non-selection signal is not inputted. About the concrete configuration of the I/O cutoff section, it mentions later.

[0028] There is no constraint of one mixer circuit in the class of device which realizes this concretely. However, it is good suitably to constitute a mixer circuit 1 using GaAsFET. Because, the microwave band IC (MMIC) using GaAsFET as an active element is the most common as a device of the high frequency stage for a migration band communication link handling more than a semi-microwave band, and secures the isolation during I/O by cutoff of a direct-current bias current, and is from *****.

[0029] Drawing 2 shows the equal circuit at the time of drain bias current cutoff of GaAsFET, i.e., a pinch-off. Here, it is gate width L_w . As 200 micrometers and bias conditions, it is the drain electrical potential difference V_d . Source electrical potential difference V_s . It is made equal and the gate and the electrical potential difference V_{gs} between the sources are set as -1V (however, pinch-off-voltage $V_{pinchoff} > V_{gs}$). Gate resistance R_g in this case, the drain resistance R_d , source resistance R_s , and the gate and capacity C_{gs} between the sources, The gate and capacity C_{gd} between drains, Each value of a drain and the capacity C_{ds} between the sources is 7.5ohm, 2.5ohm, 2.5ohm, 70ff, 70ff, and 50ff extent, respectively. And the isolation between the gate in the grounded source at this time and a drain of 20dB or more and an I/O impedance is as high as about 600 ohms in 2GHz, and can secure the level which is satisfactory practically. If multistage connection of FET is made between each RF terminal, it is possible to raise isolation further.

[0030] Drawing 3 is the circuit diagram which added the I/O cutoff section which intercepts the drain bias current of GaAsFET and performs isolation during I/O. Transistor Q_s Transistor Q_m for mixers It is DC switching element for drain current cutoff, and is Transistor Q_s by the electrical potential difference of Terminal SW. ON / off actuation is possible. Transistor Q_s At the time of OFF, it is Transistor Q_m . Since source potential rises, it is Transistor Q_m . OFF, i.e., a pinch-off condition, comes and isolation at the time of the drain bias current cutoff shown in the equal circuit of drawing 2 is realized. In addition, in the source resistance component which the sign R_{ss} which can set drawing 3 makes stabilize a drain current, and R_{01} , gate series resistance and C show the capacitor for RF touch-down, and, as for gate bias resistance and R_{02} , L shows a load inductor.

[0031] It explains referring to a drawing by drain bias current cutoff of this GaAsFET hereafter using a mixer circuit and an amplifying circuit as an example for the operation gestalt of the RF circuit which realized block selection (and interblock isolation) suitably.

[0032] 1st operation gestalt drawing 4 is the circuit diagram of the RF mixer circuit concerning the 1st operation gestalt. In the 1st mixer circuit block 2, the transistor Q_{11} for mixers of dual gate structure is formed, and the transistor Q_{12} for mixers of dual gate structure is similarly formed in the 2nd mixer circuit block 3. The drains interconnect and these two transistors Q_{11} and Q_{12} for mixers are the common IF output terminals IFout. It connects. The 1st gate of the transistor Q_{11} for mixers is the RF input terminal RFin1. Connecting, the 1st gate of the transistor Q_{12} for mixers is the RF input terminal RFin2. It connects.

[0033] Since the transistor Q_{13} for LO magnification or Q_{14} is high interest profit-ization, cascade connection is carried out to the transistors Q_{11} and Q_{12} for mixers. That is, the drain of the transistor Q_{13} for LO magnification is connected to the 2nd gate of the transistor Q_{11} for mixers, and the drain of the transistor Q_{14} for LO magnification is similarly connected to the 2nd gate of the transistor Q_{12} for mixers. In addition, it is the joint capacity C_2 between the joint capacity C_1 , the transistor Q_{12} for mixers, and the transistor Q_{14} for LO magnification between the transistor Q_{11} for mixers, and the transistor Q_{13} for LO magnification. It intervenes, respectively. Each 1st gate of the transistor Q_{11} for mixers and Q_{12} is resistance R_1 , respectively. Or R_2 It is minded and grounded. Similarly, each 2nd gate of the transistor Q_{11} for mixers and Q_{12} is resistance R_3 , respectively. Or R_4 It is minded and grounded. Each joint capacity C_1 and C_2 The connection node between the transistor Q_{13} for LO magnification and the drain of Q_{14} is the supply terminal Vdd1 of supply voltage,

respectively. Or Vdd2 It connects. The 1st gate is connected to the common LO input terminal LOin, and the transistor Q13 for LO magnification and Q14 are resistance R5, respectively. Or it connects with touch-down potential through R6. Transistor Q13 for LO magnification The 2nd gate of Q14 is resistance R7, respectively. Capacity C3 or resistance R8 Capacity C4 Parallel connection is carried out between touch-down potentials, and RF-touch-down is taken.

[0034] They are the transistor Q15 for an output switch, and Q16 and the source resistance component Rss1 between the source of the transistors Q11 and Q12 for mixers, and touch-down potential. A series circuit is the touch-down capacity C5, respectively. Or C6 It connects with juxtaposition. Similarly, they are the transistor Q17 for an input switch, and Q18 and the source resistance component Rss2 between the transistor Q13 for LO magnification, and the source of Q14 and touch-down potential. A series circuit is the touch-down capacity C7, respectively. Or C8 It connects with juxtaposition. The transistor Q15 for these switches, and Q16, Q17 and Q18 have single gate structure. the transistor Q15 for a switch, and the gate of Q17 -- respectively -- resistance R9 R11 [or] -- minding -- 1st switch terminal SW1 it connects -- having -- the transistor Q16 for a switch, and the gate of Q18 -- respectively -- resistance R10 or R12 -- minding -- 2nd switch terminal SW2 It connects. Source resistance components Rss1 and Rss2 which the "I/O cutoff section" of this invention is constituted by these quantity resistance R9 -R12 and the transistors Q15-Q18 for a switch, and are between blocks, and were prepared in common It corresponds to the "load component" of this invention.

[0035] In addition, in drawing 4 , it has omitted about the matching circuit of I/O. Moreover, the input to the transistor for mixers of a RF signal and LO signal may input LO signal into reverse, i.e., the 1st gate, and may input a RF signal into the 2nd gate. In the circuitry of this operation gestalt, since conversion gain can be obtained in the mixer section (transistor for mixers), especially the IF amplifier has not been formed, but in order to raise conversion gain further, an IF amplifier may be formed in the latter part of the mixer section.

[0036] Below, about actuation of the high frequency mixer circuit 1 constituted in this way, the 1st mixer circuit block 2 is chosen and the case where un-choosing the 2nd mixer circuit block 3 is supposed is explained to an example. In this case, a selection signal is the switch terminal SW1 of the 1st mixer circuit block 2. It is impressed and a selection signal and the non-selection signal of opposition are the switch terminal SW2 of the 2nd mixer circuit block 3. It is impressed. For this reason, both two transistors Q15 for a direct-current switch in the 1st mixer circuit block 2 and Q17 will be in switch-on, and both two transistors Q16 for a direct-current switch in the 2nd mixer circuit block 3 and Q18 will be in non-switch-on.

[0037] the inside of the 1st mixer circuit block 2 -- the transistor Q11 for mixers -- IF output terminal IFout from -- the path of the drain bias current by supply voltage VDD is secured, and operating state is prepared. Moreover, also about the transistor Q13 for LO magnification, the path of a drain bias current is secured and operating state is prepared. When LO signal is inputted from the LO input terminal LOin in this condition, it is amplified with the transistor Q13 for LO magnification, and LO signal is the joint capacity C1. It minds and is inputted into the 2nd gate of the transistor Q11 for mixers. moreover, RF input terminal RFIn1 from -- a RF signal will be mixed with LO signal by this transistor Q11 for mixers, if a RF signal is inputted and it is impressed by the 1st gate of the transistor Q11 for mixers. The signal of the various frequencies which contain an IF signal in the output of the transistor Q11 for mixers according to a difference of the frequency of LO signal and a RF signal appears, and it is the IF output terminal IFout. It is led. henceforth -- this IF output terminal IFout from -- an IF signal is taken out by passing a low pass filter etc. in a signal.

[0038] On the other hand, since two transistors Q16 for a switch and Q18 will be in non-switch-on, as for both the 2nd mixer circuit blocks 3, both the transistor Q12 for mixers and the transistor Q14 for LO magnification will be in a drain current cutoff (pinch-off) condition.

For this reason, P1 of RF input side shown in drawing 4 while actuation of the 2nd mixer circuit block 3 is suspended P2 of a point and a mixing output side P3 of a point and LO input side About a point, the RF-isolation of that mutual is fully attained. consequently, RF input terminal RFin2 of the 2nd mixer circuit block 3 ***** a signal is inputted -- this -- IF output terminal IFout from -- it decreases to the level in which a signal is hardly affected and interference between systems does not have a problem practically.

[0039] The 2nd operation gestalt book operation gestalt illustrates the 1st of drawing 1, and other gestalten of the 2nd high frequency circuit block 2 and 3, and drawing 1 - drawing 3 are applied also in this operation gestalt.

[0040] Drawing 5 is the circuit diagram of the RF mixer circuit concerning this operation gestalt. This RF mixer circuit 10 shows the example of a circuit with two RF input terminals in which actuation by the positive supply voltage by enhancement type GaAsFET is possible, and has omitted it about the matching circuit like the case of the 1st operation gestalt.

[0041] The transistor Q19 for mixers in this circuitry and Q20 have single gate structure, and it is used for them as a switch mold which does not impress an electrical potential difference between a drain and the source. That is, LO signal is inputted into the gate and a RF signal is inputted into one side of the source and a drain, and it connects so that the signal after mixing may be taken out from another side of the source and a drain. When more detailed connection relation is described, it is the RF input terminal RFin1 to the transistor Q19 for mixers, the source of Q20, and one side of a drain. Or RFin2 It connects and the transistor Q13 for LO magnification of dual gate structure or Q14 is the joint capacity C1, respectively like [the transistor Q19 for mixers, and the gate of Q20] the 1st operation gestalt. Or C2 It minds and connects. For the transistor Q13 for LO magnification, or Q14, the 1st gate is connected to the common LO input terminal LOin, and the 2nd gate is the capacitor C3 for RF touch-down. Or C4 It is grounded in RF. The bias voltage of the 1st and 2nd gates of these transistors Q13 and Q14 for LO magnification is set up by R21-R24 other than resistance R5-R7. The other side of the transistor Q19 for mixers, and the source of Q20 and a drain is the joint capacity C9 while connecting with touch-down potential through resistance R13 or R14. Or it connects with the gate of the transistors Q21 or Q22 for IF magnification of single gate structure through C10. This transistor Q21 for IF magnification and the drain of Q22 are communalized, and this common node is the IF output terminal IFout. It connects. IF output terminal IFout from -- it is the same as that of the case of the 1st operation gestalt to have adopted the configuration which receives supply of supply voltage VDD. For this reason, between the transistor Q21 for IF magnification, the drain of Q22, and touch-down potential, the series connection of two resistance R15 and R16, or R17 and R18 was carried out, respectively, and the gate bias point is set up by that resistance division.

[0042] Moreover, the bias circuit is connected to the transistor Q19 for mixers of this operation gestalt, and the gate of Q20. In this bias circuit, they are [load resistance RL1 or RL2 and] about 200 micrometers and gate width Wg between the point (the transistor Q21 for IF magnification and Q in this case 22 gates) supplying [bias], and touch-down potential. It is comparatively alike and series connection of the big transistors Q23 or Q24 is carried out, respectively. The gate and the drain of these transistors Q23 and Q24 are short-circuited, and, moreover, are connected to touch-down potential through capacity C11 or C12. Moreover, this transistor Q23 and the gate of Q24 are connected to the gate of the transistors Q19 or Q20 for mixers through the high impedance component (here resistance R19 or R20).

[0043] Thus, the bias circuit is constituted because the transistor Q19 for mixers in this circuitry and Q20 are used as a switch mold which does not impress an electrical potential difference between a drain and the source. When an electrical potential difference is not impressed between a drain and the source but a property is generally greatly dependent on gate bias voltage, the current feedback mold usually used abundantly as a bias circuit cannot be used. If the conversion efficiency (mixing effectiveness) is greatly dependent on the gate

bias voltage V_{gg} , for example, the gate bias voltage V_{gg} shifts from the set point by the variation on manufacture of the gate threshold voltage V_{th} , a mixing loss will generate the transistor Q19 for mixers of a switch mold, and Q20. It sets to this bias circuit and they are a transistor Q23 and the gate width W_g of Q24. If load resistance $RL1$ and $RL2$ are set as a sufficiently big value, the gate bias voltage V_{gg} can be brought close to the gate threshold voltage V_{th} , and moreover it can be made to be able to change with the gate threshold voltage V_{th} , consequently generating of a mixing loss can be prevented effectively.

[0044] Also in this operation gestalt, the I/O cutoff section of the almost same configuration as the 1st operation gestalt is built in in each mixer circuit block. However, since the drain current is considering as the configuration which does not flow essentially the transistor Q19 for mixers, and Q20 in the case of this operation gestalt, the transistor Q15 for an output switch and Q16 are connected to the transistor Q19 for mixers, and not Q20 but the transistor Q19 for IF magnification, and the source of Q20. This transistor Q19 for IF magnification and the source of Q20 are connected to touch-down potential through capacity C13 or C14, respectively.

[0045] The fundamental actuation is the same as that of the 1st operation gestalt almost except that a RF signal is inputted from a transistor [with which the gate bias voltage V_{gg} was optimized by the bias circuit the mixer circuit of this operation gestalt can respond by the positive supply] Q19 for mixers, drain [of Q20], or source side, and the signal after mixing being amplified by the transistor Q21 for IF magnification, and Q22, and being taken out. (Moreover, the same effectiveness SW1 and SW2 as the 1st operation gestalt, i.e., switching terminals, According to the logic state of the signal inputted, the pair of a transistor Q15, Q17, a transistor Q16, and either of Q18 will be in non-switch-on alternatively, actuation of the mixer circuit block of one of these is stopped, and it is the IF output terminal IFout. The receiving RF-insulation is fully attained.)

[0046] With the 3rd operation gestalt book operation gestalt, in order to illustrate that this invention can apply besides a mixer circuit, the RF amplifying circuit of the one-step configuration which consists of two lines is explained.

[0047] Drawing 6 is the circuit diagram showing the outline configuration of this RF amplifying circuit. This RF amplifying circuit 20 is replaced with the current supply electronic switch 123 of a circuit 120 conventionally which is shown in drawing 12, and adds a drain bias cutoff function to the basic configuration within each block. Each configuration of the input matching circuit 111 in drawing 6, the output matching circuit 112, the transistor Q30 for high frequency magnification, the gate bias resistance R30, R31, the capacitor C10 for high frequency touch-down, C11, and the load inductor L is the same as usual. Moreover, it is the RF input terminal RFin1 for every block. Or RFin2 It is also the same as usual to have the RF output terminal RFout1 or RFout2.

[0048] The point that two circuit blocks 21 and 22 of the high frequency amplifying circuit 20 of this operation gestalt differ from a configuration conventionally is the series connection of the transistor Qs1 for a direct-current switch, or Qs2 and the source resistance component R_{ss} being carried out, and the source resistance component's R_{ss} being between blocks, and moreover, communalized between the source of the transistor Q30 for high frequency magnification, and touch-down potential. That is, the 1st and 2nd circuit block 21, two transistors Qs1 for a direct-current switch in 22, and the sources of Qs2 short-circuit, and the above-mentioned source resistance component R_{ss} is inserted between the node and touch-down potential. Moreover, a switch terminal is prepared for every circuit block, and it is each transistor Qs for a direct-current switch. The gate minds the gate series resistance R32, respectively, and is the switch terminal SW1. Or SW2 It connects. furthermore, a power supply terminal Vdd and the touch-down capacity C10 are formed only in one circuit block (drawing 6 the 1st circuit block 21) -- having -- the load inductor L of a circuit block of another side -- on the other hand, the edge is connected to the power supply terminal Vdd of

one circuit block.

[0049] In such a RF amplifying circuit 20 of a configuration, supply voltage V_{DD} is supplied to a power supply terminal V_{dd} , and one circuit block is operated alternatively. Switch terminal voltage V_{sw2} of the now, for example, 2nd circuit, block 22 High level and switch terminal voltage V_{sw1} of the 1st circuit block 21 It considers as a low level. Thereby, the transistor Q_{s1} for a direct-current switch within ON and the 1st circuit block 21 turns [the transistor Q_{s2} for a direct-current switch within the 2nd circuit block 22] off, and, only in the transistor Q_{30} for high frequency magnification within the 2nd circuit block 22, a drain bias current (operating current) flows. After this 2nd circuit block 22 was chosen and the 1st circuit block 21 has been un-choosing, it is the RF input terminal R_{Fin2} . Although the RF signal inputted is outputted from the RF output terminal R_{Fout2} after magnification, the signal after magnification is not outputted from the RF output terminal R_{Fout1} of another side.

[0050] In this actuation, the operating current i flows for the source resistance component R_{ss} from the transistor Q_{s2} for a direct-current switch which is in an ON state within the 2nd circuit block 22. consequently, the independent case where the source resistance which the source potential of the transistor Q_{s1} for a direct-current switch which is in an OFF state within the 1st circuit block 21 of another side shows to drawing 13 is not communalized -- comparing -- a part for the voltage drop V_s of the source resistance component R_{ss} only -- it goes up. this -- the former -- comparing -- the gate of the transistor of an OFF state, and electrical potential difference V_{ds} (off) between drains relative -- V_s only -- it means making it shift in the negative electrical-potential-difference direction. Consequently, switch terminal voltage V_{sw1} of a low level When it is made to change high-level, the operating voltage margin of the OFF state in selection actuation of a circuit block is expanded.

[0051] In addition, although not explained in full detail in previous explanation, also in said 1st and 2nd operation gestalten, the configuration which connects the transistor for a direct-current switch to the source of a high-frequency transistor, is between blocks, short-circuits that source, and is grounded through a load component is the same as that of this 3rd operation gestalt, and does the same effectiveness so. With the 1st operation gestalt, the transistors Q_{21} and Q_{22} for IF magnification correspond to the "high-frequency transistor" of this invention in the transistors Q_{11} and Q_{12} for mixers, and the 2nd operation gestalt.

[0052] Finally, the result of having verified operating voltage margin expansion of this OFF state in the concrete example of a prototype is described in the example of application to a RF mixer circuit.

[0053] The switch terminal voltage dependency of the conversion gain at the time of making the circuit of above-mentioned drawing 5 as an experiment to drawing 7 and drawing 8 is shown. Like the case of drawing 14 and drawing 15 which were used when a prototype sample here pointed out the conventional technical problem, the device was GaAsJFET and the pinch-off-voltage $V_{pinchoff}$ was about 0.1V-0.2V. Moreover, potential v_s of the point in the RF mixer circuit 10 (drawing 5) made as an experiment connecting [source] too hastily They are the source resistance component R_{ss1} and R_{ss2} so that it may be set to 1.2V-1.3V. Resistance is set up. In addition, supply voltage V_{DD} at the time of this circuit measurement was set to 2.7V.

[0054] In drawing 5, drawing 7 makes an ON state an OFF state and the 2nd mixer circuit block 3, sets the 1st mixer circuit block 2 to the 1st mixer circuit block 2, and is the switch terminal $SW1$. Terminal voltage V_{sw1} It is the graph which shows transition of the conversion gain in the 2nd mixer circuit block 3 at the time of making it change. As a parameter, it is the switch terminal $SW2$ of another side. Terminal voltage V_{sw2} It takes and the case where this is 2.0V and 2.7V is shown. Terminal voltage V_{sw1} to which conversion gain begins to decrease greatly from this graph It is 1.3V-1.4V, and this is the source resistance edge electrical potential difference v_s . It is equal to the sum of pinch off voltage,

therefore it turns out that the margin ($V_{sw1} - V_{pinchoff}$) of the operating voltage at the time of OFF is securable V or more [1]. The operating voltage margin at the time of this OFF is the switch terminal SW2. Terminal voltage V_{sw2} Even if it lowers to 2.0V from 2.7V, effect is hardly received in this.

[0055] Drawing 8 sets ON and the 2nd mixer circuit block 3 to OFF for the 1st mixer circuit block 2, and is the terminal voltage V_{sw2} of the 2nd mixer circuit block 3. It is the graph which shows transition of the conversion gain in the 2nd mixer circuit block 3 at the time of making it change in the ON direction. This conversion gain is the terminal voltage V_{sw1} of a block of an ON state. Although it depends a little, a RF property is the terminal voltage V_{sw2} at the time of OFF like the case of drawing 7. It is changing a lot in the 1.3V - 1.4V neighborhood, the margin of operation at the time of OFF is expanded from this, and it is terminal voltage V_{sw2} . If it is less than [1V], it turns out that the stable RF barrier property is acquired.

[0056] In this example of a prototype, since the operating voltage margin at the time of OFF secured V or more [1], after securing the high frequency barrier property at the time of OFF, even if, as for the minimum pinch off voltage of a high-frequency transistor, assumption **** regards allowances as 0.3V, about -0.6V can permit the electrical-potential-difference margin upper limit of switching. Therefore, if the pinch-off-voltage range in case a high-frequency transistor is MESFET is the case of JFET, it is expandable to about -0.6V-+0.3V again about -0.6V-+0.6V. Consequently, even if it takes the variation in a manufacture process into consideration, although GaAsFET etc. is excellent in a high frequency property, about the high frequency circuit where the pinch-off-voltage range based on diffusion potential consisted of narrow devices, the actuation is stabilized and monolithic-ization of a bias current cutoff function is attained.

[0057]

[Effect of the Invention] According to the high frequency circuit concerning this invention, the pinch off voltage of the high-frequency transistor which is in an OFF state within a circuit block [**** / un-] expands the load component by which the operating current which flows the inside of a selection-circuitry block was connected to the common source by the voltage drop when flowing, consequently the operating voltage margin of the OFF state of the non-selection-circuitry block concerned is expanded. for this reason, from the first, the pinch-off-voltage range is narrow and monolithic-izing of a bias current cutoff function was difficult -- high -- highly efficient MMIC becomes realizable variously by small [outstanding / of a property] using a property high frequency device.

[0058] Moreover, when this invention is applied to a mixer circuit, by using the high isolation property between each terminal at the time of drain current cutoff of GaAsFET etc., complicated circuitry according the mold mixer circuit corresponding to a multisystem corresponding to two or more RF frequency bands to a high frequency switch etc. is not needed, but it becomes possible to constitute from space-saving simply.

CLAIMS

[Claim(s)]

[Claim 1] It is the RF circuit where said two or more circuit blocks of each have the transistor for a direct-current switch which intercepts the path of a direct-current bias current of flowing the inside of the circuit block concerned based on the non-selection signal inputted, respectively by having two or more circuit blocks into which the RF signal which received is inputted when the block is not chosen.

[Claim 2] Said transistor for a direct-current switch is a RF circuit according to claim 1 which the source is between circuit blocks, and intercepts the drain as said direct-current bias

current, and the current between the sources when it connects mutually, it connects with the supply line of a common electrical potential difference through a common load component and said non-selection signal is impressed to the gate.

[Claim 3] The drain of said transistor for a direct-current switch is a RF circuit according to claim 1 where it connects with the source of the high-frequency transistor within the same circuit block as the transistor for a direct-current switch concerned, and the capacitor for RF touch-down is connected between the source of the high-frequency transistor concerned, and the supply line of said common electrical potential difference.

[Claim 4] The high frequency circuit according to claim 3 which has the transistor for high frequency magnification which amplifies the RF signal inputted into the gate as said high-frequency transistor, and is outputted from a drain side.

[Claim 5] Said high-frequency transistor is a RF circuit according to claim 3 which is a gallium arsenide field-effect transistor.

[Claim 6] It has two or more mixer circuit blocks which mix a RF signal with local oscillation signalling frequency, and output an IF signal for every frequency band of a RF signal. It has RF input terminal into which said RF signal is inputted for said every mixer circuit block. LO input terminal which inputs said local oscillation signalling frequency, and each IF output terminal which outputs said IF signal. It is between all mixer circuit blocks, and is communalized. Said two or more mixer circuit blocks. When a RF signal peculiar to the block is not chosen. The RF circuit which has at least the I/O cutoff section which fully raises the RF-insulation of said IF output terminal to said RF input terminal, respectively by intercepting the path of a direct-current bias current of flowing the inside of the mixer circuit block concerned based on the non-selection signal inputted.

[Claim 7] Said I/O cutoff section is a RF circuit according to claim 6 which the source is between circuit blocks, and has a drain as said direct-current bias current, and the transistor for a direct-current switch which intercepts the current between the sources when it connects mutually, it connects with the supply line of a common electrical potential difference through a common load component and said non-selection signal is impressed to the gate.

[Claim 8] Supply voltage is impressed to a drain and, as for said mixer circuit block, the source is connected to said common electrical potential difference through the capacitor for RF touch-down. It has the transistor for mixers which outputs said IF signal from a drain side when said RF signal and said local oscillation signalling frequency are inputted into the gate. Said I/O cutoff section. The RF circuit according to claim 7 which has the transistor for an output switch which intercepts the operating current which flows to said transistor for mixers as said transistor for a direct-current switch when said non-selection signal is inputted into the gate.

[Claim 9] When a RF signal is inputted from said RF input terminal connected to the drain and said local oscillation signalling frequency is inputted into the gate, said mixer circuit block. Supply voltage is impressed to the transistor for mixers which outputs an IF signal from the source, and a drain. The source is connected to said common electrical potential difference through the capacitor for RF touch-down. It has the transistor for IF magnification which it connects with the source of said transistor for mixers, and the gate amplifies said IF signal inputted into the gate concerned, and outputs from a drain. Said I/O cutoff section is a RF circuit according to claim 7 which has the transistor for an output switch which intercepts the operating current which flows to said transistor for IF magnification as said transistor for a direct-current switch when said non-selection signal is inputted into the gate.

[Claim 10] Said mixer circuit block is connected between the gate of said transistor for mixers, said supply voltage supply line, or said common electrical-potential-difference supply line. It has further the transistor for LO magnification which amplifies said local oscillation signalling frequency inputted from said LO input terminal connected to the gate, and is outputted to the gate of said transistor for mixers. Said I/O cutoff section is a RF circuit

according to claim 8 which has further the transistor for an input switch which intercepts the operating current which flows to said transistor for LO magnification as said 2nd transistor for a direct-current switch when said non-selection signal is inputted into the gate.

[Claim 11] Said mixer circuit block is connected between the gate of said transistor for mixers, said supply voltage supply line, or said common electrical-potential-difference supply line. It has further the transistor for LO magnification which amplifies said local oscillation signalling frequency inputted from said LO input terminal connected to the gate, and is outputted to the gate of said transistor for mixers. Said I/O cutoff section is a RF circuit according to claim 9 which has further the transistor for an input switch which intercepts the operating current which flows to said transistor for LO magnification as said 2nd transistor for a direct-current switch when said non-selection signal is inputted into the gate.

[Claim 12] Said transistor for mixers is a RF circuit according to claim 8 which is the gallium arsenide field-effect transistor of the dual gate structure of having the 1st gate electrode connected to said RF input terminal, and the 2nd gate electrode into which said local oscillation signalling frequency is inputted.

[Claim 13] Said transistor for a direct-current switch is a RF circuit according to claim 7 which is a gallium arsenide field-effect transistor.